Performance Of Troposcatter Communications with Different Diversity Technique on Fading Correlation Analysis

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ABSTRACT: The capacity gain of MIMO systems significantly depends on the fading correlation between antennas. A channel sounding experiments and One Ring model is a methods to calculate correlation but cost of these methods are high due to use of high power amplifiers and large antennas. So using ring scatter model (RSM), to derive the fading correlation in the troposcatter systems as a function of space-frequency diversity or space-angle diversity to achieve the greater gain by decreasing the fading correlation.

INDEXTERMS: Fading, Correlation, Ring Scatter Model, MIMO, Diversity methods.

I. INTRODUCTION
Troposcatter systems were evolved in the 1950s. Main application of troposcatter is point to point communications beyond line of sight (over the horizon), that is where the sending and receiving antennas are not visible. In troposcatter, transmission of signals are forwarded by scatter of the electro magnetic waves in the troposphere, the first division of the earth’s ecosystem. In troposcatter signal transmission depends on high power transmitters and sensitive receivers, because as the forward scatter path loss is relatively high due to mountain, clouds, and temperature variations when compared to conventional microwave line of sight systems. The hallmark of troposcatter radio systems is their long distance operation, beyond line of sight, and their dependence on the earth’s atmosphere.

![Figure 1: Transmission of Troposcatter Beyond the Horizon](image)

The intersection of the antenna beam-widths are denoted as troposcatter common volume and the receiver can receive the scattered rays only in this region. Therefore, troposcatter can be used as a communication medium for high data rate beyond Line-of-Sight (b-LoS) transmission with its low transmission delays and high capacity. The available b-LoS communications mostly utilize satellite communications (SATCOM).

In Troposcatter radio waves propagate through troposphere, it acts like wave guide. The troposphere is the nearest portion (1st portion above the earth) of earth’s ecosystem, about 8 to 15 km above the earth’s surface. The troposphere is where most clouds form, precipitation occurs.
Electromagnetic waves (or) signals are transmitted through the troposphere by forward scatter,[3] which occurs as a result of irregularities in the radio refractive index of the troposphere. An example of a troposcatter radio path is shown above in Figure 2. Troposcatter medium is a lossy wave-guide due to high path lengths and scattering. So it is required to implement the diversity techniques to provide reliable and high data rate b-LoStroposcatter systems. The main diversity techniques for the troposcatter communications are space, frequency and angle diversity.

We have two methods to calculate fading correlation analysis in MIMO-OFDM troposcatter communication is channel sounding experiments and one ring model. One Ring model is a methods to calculate correlation, is extensively used to describe macro cellular scenario where the base station is elevated and it can be considered to devoid of surrounding scatters. It may be noted that this model considers the coupling among the antenna elements. However, the cost of channel sounding experiments for troposcatter is too high due to the requirement for high power amplifiers and large antennas.

II. RING SCATTER MODEL
The troposcatter power lean on both the path geometry and the atmospheric turbulence. Therefore, these factors will have strong effects on the correlation analysis. The troposcatter is caused by the atmospheric scintillations due to the varies in the refractive index of the atmosphere. According to the turbulence characteristics, the scattering can be modeled as single or multiple scat
The microwave propagation in the troposphere is related to the tenuous distribution of the particles, and it can be modeled with the first order multi-scattering approximation in the tenuous medium for a unit particle as

$$P_r = P_t \frac{\sigma N \lambda}{4 \pi} W,$$

Where $\lambda$ is the wavelength, $P_t$ is the transmitter power and $P_r$ is the receiver power. $G_t$ and $G_r$ are the antenna gains which are modeled with Gaussian pattern. $R_t$ and $R_r$ are the distances between scattering point to transmitter and receiver respectively.

In troposcatter common coincidence area considered as a common volume. Only the scattered rays inside the common volume of troposcatter can be received due to path geometry as in Fig. 3. The scattered rays outside of this region will reach the receiver with either lower or higher angles than the 10 dB beam-width of the receiver. Although the scattering particles are located through the troposphere, we only consider the scatters that are located in a ring within the intersection of the transmitter and receiver 10 dB beam-widths as in Figure 2. The boundaries for the scatters is given as $\theta$ in $[-\pi, \pi]$ and $r$ in $[0, R_{10dB}]$. The radius of the rings are given by

$$r_{3dB} = R_t \sin \left( \frac{W_{3dB}}{2} \right)$$
$$r_{10dB} = R_t \sin \left( \frac{W_{10dB}}{2} \right)$$

where $R_t$ is the path between the center of the rings and transmitter. $W_{3dB}$ and $W_{10dB}$ are the transmitter 3 dB and 10 dB beam-widths, respectively.

To maximize the received power, the 3dB beam-widths of antennas are adjusted to the radio horizon as shown in Fig. 3. Therefore, the lower part of the ring (the darker region in Fig. 2) will be blocked by the path geometry due to the curvature of the earth. Since RSM method utilizes the 10 dB beam-widths, the lower part of the ring will be eliminated from the correlation calculations

### III. MIMO-OFDM

![OFDM Transmitter and receiver](image)

Figure 4: OFDM Transmitter and receiver

The main objective of a MIMO-OFDM is to transmit and receive a no of signals at a time. OFDM is a technique which transmits a wide band signal into a narrow band signal by dividing it. Each narrow band signal is carried by separate carrier frequency, all these narrow band frequencies are placed in orthogonally, so no ISI (inter symbol interference) will occur. FDM (frequency division multiplexing) is similar technique but it require guard band for avoiding ISI. This guard band takes additional bandwidth so automatically large bandwidth is required for sending large amount of data. In OFDM each frequency signal is converted into time domain. This are send into free space by convert to the analog form. At receiver each signal is recover
by in the form of frequency domain using FFT and each signal is separated by using decoder. The main advantage is, if deep fade occur only one or two symbols only distorted remaining message will same as transmitter send. For avoiding this type of fading we introduce cyclic prefix.[10,12]

IV. NEED OF DIVERSITY

In wireless telecommunications, propagation is done by multipath phenomenon that results in radio signals are received by the Rx antenna by two or more multiple paths. Causes of multipath include atmospheric ducting, ionospheric reflection and refraction, and terrestrial objects such as hills and buildings. The effects of multipath include interference, that is amplitude variation and phase of the signal may shift, so becomes fade. To avoiding fading we need a technique diversity. Diversity is usually engaged to reduce the depth and time delay of the fades experienced by the Rx in flat fading channel. Diversity can be achieved by using different types those are space, frequency, angle and space-frequency.

CORRELATION: Correlation is a statistical method that determines the degree of relationship between two different variables. It is also known as a “bivariate” statistic, with bimeaning two and variate indicating variable or variance.

Positive Correlation: If the values of two variables changing in same manner then it is called to be positive correlation

Negative Correlation: If the values of variables change with opposite direction, then it is said to be negative correlation when

Pearson’s ‘r’ is the most common correlation coefficient. Karl Pearson’s Coefficient of Correlation denoted by ‘r’ The correlation coefficient ‘r’ measure the degree of linear relationship between two variables say x & y. Karl Pearson’s Coefficient of Correlation denoted by ‘r’, range is -1 ≤ r ≥ +1. Degree of Correlation is expressed by a value of Coefficient When deviation taken from an assumed mean:

\[ r = \frac{n\Sigma xy - \Sigma x \Sigma y}{\sqrt{n \Sigma x^2 - (\Sigma x)^2} \sqrt{n \Sigma y^2 - (\Sigma y)^2}} \]

V. DIVERSITY TECHNIQUES

1. SPACE DIVERSITY

Space or Spatial Diversity is most widely used technique. In this, number of antennas are used to achieve different forms (copies) of the transmitted signal. Using two antennas with a separation among them the phase delay makes multi-path signals observing at the antennas for different fading. Space diversity is nowadays in focus because of the higher frequencies used for transmission making it possible to apply this kind of diversity mechanics in smaller terminals.

Space diversity requires 100 wavelength separation between antennas, measured from the center point of each antenna. At 4.5 GHz, this is approximately 7 meters.
In these fading, correlation depends on beam width, because if we increase beam width the common volume area is increase so there is lot of space for scattering. So increasing the beam width the correlation is decreased due to increase the common volume. In another way if we increase the distance between antenna (i.e. at least 100 wavelength distance) then common volume increase hence chance of correlation is decrease.

2. FREQUENCY DIVERSITY

Frequency diversity utilizes transmission of the same signal at two different, spaced, frequency carriers achieving two independently fading versions of a signal. It is an expensive mechanism to use due to difficulties to generate several transmitted signals and the combining signals received at several different frequencies simultaneously.

Figure 6: Frequency diversity

In frequency diversity one antenna with dual polarity, is used for both transmit and receive and transmit on two frequencies, vertical and horizontal. It requires 1% frequency spacing for effective diversity (approximately 50 MHz)

3. ANGLE DIVERSITY

In angle diversities signals arriving at the antennas from different directions. So these signals have different fading variations. These signals can be used for angle or angular diversity. Angle diversity can be achieved at a mobile Rx using two Omni directional antennas, those acting as parasitic elements to each other and changing their patterns to manage the receiving of signals at different angles. In Fig 7., two orthogonal antennas are engaged on a single base at different angles.[5]

Figure 7: Angle diversity

Vertical angle diversity is also a promising method for the troposcatter communications because 2 × 2 vertical angle diversity system can form four different troposcatter common volumes. In addition, the angle diversity...
receivers can be mounted on the same parabolic reflector. Therefore, the cost of additional antennas will be low compared to space diversity. When the angle spacing of the antennas are higher than the beam-width of the antennas, the common volumes of troposcatter will not intersect, and there will be low correlation between the troposcatter common volumes.

4. SPACE-FREQUENCY DIVERSITY

Troposcatter systems can also use the combination of diversity techniques. Space-frequency diversity is a promising technique which can provide higher data rates with low cost. Space-frequency diversity systems utilize horizontally placed antennas with frequency diversity. Since the frequency diversity antennas can be mounted on the same parabolic reflector antenna, higher gains can be achieved with the space-frequency diversity by using the same number of parabolic reflector antennas as in space diversity.

CONCLUSION

In this paper, RSM for fading correlation is proposed to investigate the fading correlation between antennas for frequency, angle, space, and space-frequency diversity. According to analysis space-frequency diversity systems can provide more than 10% increase in the achievable data rates. Since the implementation of frequency diversity does not require additional parabolic reflector, space-frequency diversity systems are much more economical compared to adding additional antennas. But in angle diversity no additional antennas are required, it uses antennas which is used in space diversity so space angle diversity is another method for economic.

REFERENCES